Coastal Ocean Modeling and Observation Program
(COMOP-II)

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LONG-TERM GOALS

The long-term goal of our coordinated ONR (COMOP-II/HyCODE) and NOPP research efforts is the development and validation of a relocatable coastal ocean forecasting system. The forecasting system will consist of a coupled atmospheric-hydrodynamic-biological data-assimilative numerical model and a multi-platform real-time adaptive sampling network for use in physical/bio-optical and sediment transport applications worldwide.

OBJECTIVES

Specific objectives of the COMOP-II effort include: (a) Conduct fourth and final Coastal Predictive Skill Experiment (CPSE) at LEO in collaboration with HyCODE, utilizing a comprehensive coastal prediction system incorporating atmospheric, benthic and bio-optical submodels; (b) Extend the modeling system to provide the larger-scale modeling context for the CBLAST (Low) experiment in summer 2002; (c) Synthesize datasets and model simulations from the four (1998-2001) LEO field seasons; (d) Evaluate ocean model metrics in multiple regions; and (e) Implement a two-way-coupled atmosphere-ocean prediction system utilizing the ROMS and COAMPS models.

APPROACH

We are conducting a series of Coastal Predictive Skill Experiments (CPSE) each summer at the Long-term Ecosystem Observatory (LEO-15) offshore of Tuckerton, NJ. Model and observation network improvements tested each winter with existing data are used in an operational setting the following summer. Our phenomenological focus is on the physics of the recurrent upwelling centers that form along the southern New Jersey coast and their impact on phytoplankton distributions, in-water optical properties and dissolved oxygen. Coordinated shipboard (physical and bio-optical) and multiple AUV adaptive sampling surveys of the upwelling centers are conducted based on real-time remote sensing and *in situ* observations and model forecasts. Predictions are carried out using a hierarchy of nested and/or coupled sub-models, including: the COAMPS regional mesoscale atmospheric model, the ROMS regional ocean model, and a multi-component bio-optical model *(EcoSim)*, and supporting packages for data assimilation, visualization and model assessment.

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14. ABSTRACT

The long-term goal of our coordinated ONR (COMOP-II/HyCODE) and NOPP research efforts is the development and validation of a relocatable coastal ocean forecasting system. The forecasting system will consist of a coupled atmospheric-hydrodynamic-biological data-assimilative numerical model and a multi-platform real-time adaptive sampling network for use in physical/bio-optical and sediment transport applications worldwide.

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WORK COMPLETED

The LEO physical/bio-optical observatory was operated during the July 2001 CPSE in its most extensive configuration to date. Real-time satellite data was acquired from AVHRR, SeaWiFS, FY1-C, MODIS and Oceansat for mission planning. Aircraft operations included simultaneous flyovers of PHILLS, PHILLS-2 and AVIRIS hyperspectral aircraft at three altitudes, with additional overflights of PROTEUS and SPECTIR aircraft. The standard CODAR fields normally acquired at LEO and assimilated by the model were extended with four long-range CODAR systems that provided real-time coverage over most of the New York Bight continental shelf. Shipboard subsurface sampling of the farfield was conducted with the R/V Endeavor, and of the nearfield with the R/Vs Caleta (physics), Walford (bio-optics) and Northstar (bio-optics). AUV operations centered on further flight tests of the Webb Glider and bioluminescence applications with the REMUS. Our most extensive cross-shore model validation array was installed, consisting of 6 sites each equipped with an ADCP and thermistors. Freewave and radio communications between ships, aircraft and shore were upgraded to improve coordination within the fleet. The quick recovery of a missing Glider AUV was attributed to a freewave message sent through the PHILLS aircraft to the recovery vessel already at sea.

The Rutgers Regional Ocean Modeling System (ROMS) was run in real-time during the July, 2001 CSPE with surface forcing supplied by a high-resolution regional implementation of the Navy's COAMPS model (6 km grid, 0.5 hour archiving) as well as the standard operational COAMPS results available through MEL (27 km grid, 6 hour archiving). Available options for surface mixed layer dynamics in summer 2001 included the K Profile Parameterization (KPP) and the Mellor-Yamada level 2.5 closures; at the bottom, an inverted form of the KPP mixing scheme (Durski, 2000) and MY2.5, together with the Styles and Glenn (2000) Bottom Boundary Layer Model (BBLM), were used. Development of the ROMS circulation model also continued on several fronts, including: addition and evaluation of capabilities for sidewall buoyancy and tidal forcing; implementation of efficient reconstruction of Lagangian drifters; development of a unified suite of data assimilation capabilities; and installation of several real-time metrics for quantitative model assessment. Bio-optical hindcasts for the July, 2001 CSPE are currently underway.

RESULTS

A major sensitivity of the ocean forecast model identified in previous years was the strong dependence on the forecast windfield. These comparisons however were conducted using different atmospheric forecast models running at different spatial resolutions and archived at different time intervals. In this final year at LEO, the atmospheric forecast model was limited to a comparison of the operational COAMPS with an experimental COAMPS run by NRL at higher resolution in space and time. The experimental COAMPS forecasts produced the best comparisons (qualitatively) with regional observations that our meteorologists have seen during the four-year time period covered by these experiments. Fig. 1 shows one of the comparison plots for the primary weather station at Tuckerton (top row) during forecast cycle 3. The period is characterized by shifting wind directions due to a nearby warm front on July 18, followed on July 19 by strong northeasterlies from a developing low moving offshore to the ESE. The higher resolution of the experimental COAMPS (middle row) captures many of these wind shifts, and the development of the strong low. The exact evolution of the operational COAMPS (bottom row) on July 18 is unknown due to the 6-hour archiving schedule, and the available fields are smoother with a less intense warm front.
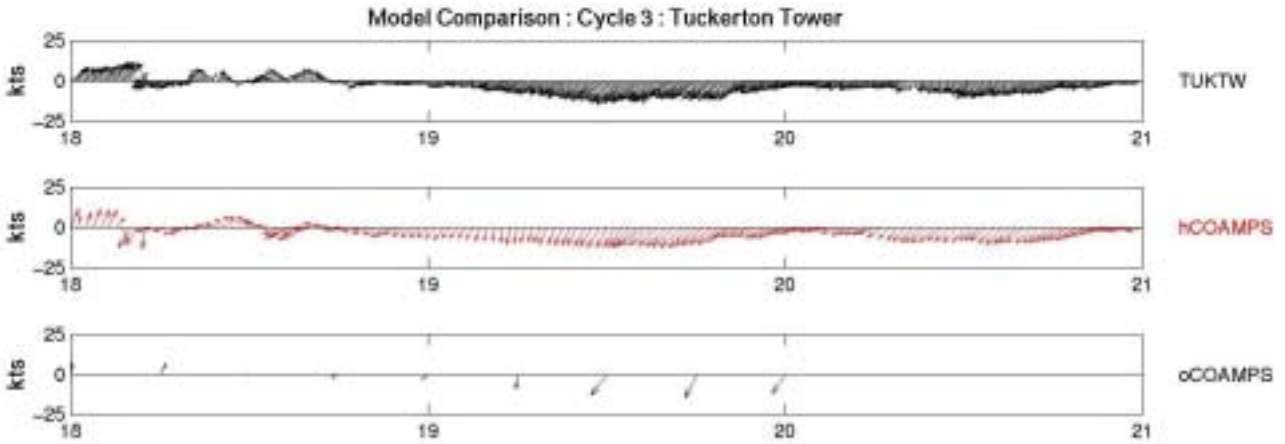
Figure 1. Meteorological Model Wind Comparison
[Three-day time series of wind comparisons of observations, high-res. and operational COAMPS, depicting wind shifts due to a nearby warm front and a deepening low moving ESE.]

The windshift on July 19 produced the most intense downwelling event of the 2001 experiment. Fig. 2a shows the surface current vectors from the standard (1.5 km resolution) and long-range (6 km resolution) CODAR systems during this event. Shipboard CTD surveys along 4 of the cross-shore lines in Fig. 2a indicate that a strong thermocline was located at a depth of 6-8 m over most of the region of interest before the event. The time series of temperature from the COOL 2 thermistor string (Fig. 2b) shows the downwelling front passing through this mooring near the end of the day on July 19. Fig. 2d shows the real-time model prediction forced by the experimental COAMPS and using the KPP closure. The downwelling front also passes through this position in the model starting late on July 19, but slightly slower. The model thermocline is slightly more diffuse, but some of its undulations on July 18 appear to be mimicked by the model. The forecast with the Mellor-Yamada closure also produced a more diffuse thermocline with a maximum gradient that oscillates between 5 and 10 m depths, and a downwelling front that does not propagate past the COOL 2 mooring even by the end of the forecast on July 20.

Initial validation metrics for the model run using the KPP closure scheme are illustrated in Fig. 2c. Red lines are the ROMS model predictions, and blue are the ocean observations. The metrics assume the ocean has two layers separated by a thermocline. The plotted lines, from top to bottom, represent the surface temperature, average surface layer temperature, average bottom layer temperature, depth of the maximum temperature gradient, and magnitude of the maximum temperature gradient. During this forecast, surface layer temperatures warm more than the observations after the downwelling event. Bottom layer temperatures indicate the timing of the frontal passage is very well represented, but the initial bottom temperatures are too warm. The depth of the thermocline is well represented before the frontal passage, and is irrelevant after, since the ocean is now a one-layer system at this point. The thermocline gradient is smaller in the model throughout the initial time period, indicating the model thermocline is not as sharp. Similar plots produced for all the forecasts at all the validation points in the cross-shelf array will be used to produce more quantitative comparisons between different atmospheric products, closures, bottom boundary layers, sidewall conditions, and assimilation schemes.
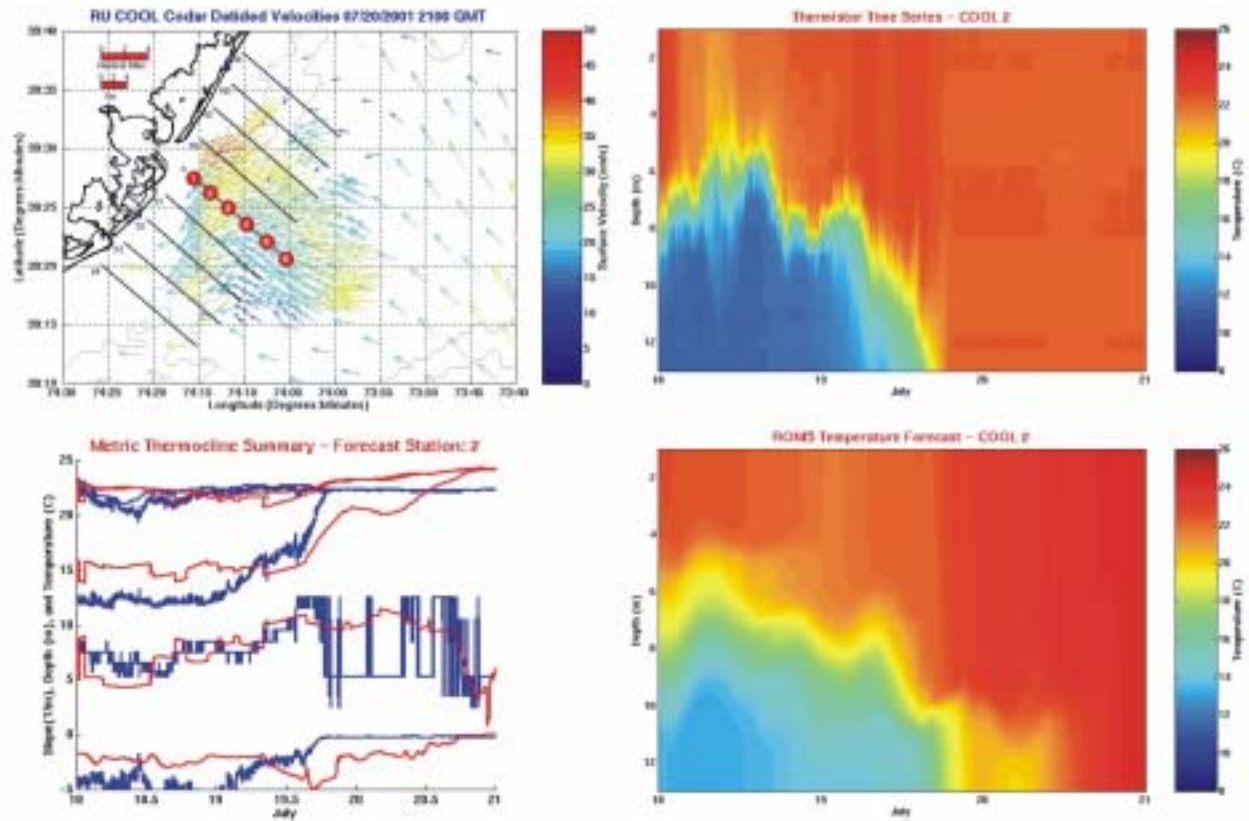
Figure 2. ROMS Model Metric Comparisons
[Clockwise from top-left: a) Map of the LEO research area, with long-range and standard CODAR
coverage, cross-shelf shipboard survey lines and COOL mooring locations (red circles).
b) Temperature time-series at mooring COOL-2 for a 3-day period in July. d) ROMS model
forecast for the same station and time period. c) Model metric comparisons for temperatures
(surface, upper layer, bottom layer), the thermocline depth and its maximum gradient (Red - ROMS,
Blue - ocean observations).]

IMPACT/APPLICATIONS

Participants in the July 2001 CPSE included over 150 scientists, students and technicians from over 25 academic, government and industrial institutions. The collaborative nature of the interdisciplinary scientific studies at LEO continues to attract new partners.

NRL atmospheric forecasters participated as full partners for the first time. Their tailored COAMPS atmospheric forecasts produced an excellent set of ocean forecasts, featuring large excursions of a bottom front in response to rapid wind shifts. Combined with the most extensive cross-shelf array we have ever deployed and recovered, an extensive database for model validation and assimilation has been generated.

Web access for the LEO datasets currently averages over 80,000 hits per day during the summer, demonstrating its usefulness for public outreach and educational programs. This has led to the

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development of a new public access web site featured on several New York and Philadelphia TV stations this summer.

TRANSITIONS

Worldwide use of the ROMS model continues to grow, including applications involving the full East and West Coasts, numerous smaller subdomains along these coasts (LEO, Gulf of Maine, Hudson River, CalCOFI), the Gulf of Alaska, and the Bering Sea. ROMS serves as the basis for the new Navy Terrain-following Ocean Modeling System (TOMS).

COMOP scientists serve as members of the steering committee for the Gulf of Maine Ocean Observatory (GoMOOS), the NorthEast Ocean Observing System (NEOOS), and the Consortium of East Coast Ocean Observatories.

Real-time data sets produced by the LEO observatory are currently being used by the Coast Guard and the Navy for operational support in the New York Bight.

RELATED PROJECTS

The ONR-sponsored HyCODE project, led by Oscar Schofield, sponsored most of the bio-optical component of the July, 2001 HyCODE/COMOP Coastal Predictive Skill Experiment.

The ONR-sponsored CODAR Rapid Environmental Assessment project is expanding the CODAR observation network offshore to the shelf break with new Long-range CODARs and onshore to the beach with Bistatic CODARs.

The ONR-Sponsored Terrain-following Ocean Modeling System (TOMS) project, led by Hernan Arango, is merging portions of the widely-used Princeton Ocean Model (POM) with ROMS to produce TOMS.

ONR and the Great State of New Jersey have sponsored the acquisition of 4 Webb Glider AUVs and the development of new communications and control software for applications in the New York Bight.

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